

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the Application of:

AKAMATSU et al.

Serial No.: 09/392,722

Filed: September 9, 1999



Group Art Unit: 2814

Examiner: D. Graybill

For: INTEGRATED ELECTRONIC DEVICE HAVING FLIP-CHIP CONNECTION WITH
CIRCUIT BOARD AND FABRICATION METHOD THEREOF

AMENDMENT

Director of Patents and Trademarks
Washington, D.C. 20231

December 26, 2000

Sir:

In response to the Office Action dated September 26, 2000, please amend the above-identified application as follows:

IN THE CLAIMS:

Please cancel non-elected claims 27-36 without prejudice or disclaimer.

Please amend claims 17-21 as follows:

17. (Amended) A method for fabricating an integrated electronic device having an electric connection connecting a first electrode of a first substrate with a second electrode of a second substrate, [both] surfaces of the first and second electrodes having repellant and [an] adhesive [tendency] tendencies to molten metal, respectively, the method comprising the steps of:

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forming a first soldering metal bump on the surface of the first electrode, the first soldering metal bump [being made of a soldering metal alloy consisting of a solid phase component and a liquid phase component at an operating temperature; and] including at least one of components of an eutectic alloy having an eutectic temperature, wherein the first soldering metal bump has a first melting temperature;

[forming an electric connection between the first electrode and the second electrode by heating the soldering metal alloy so as to adhere to the surface of the second electrode]

B1 cont.
forming a second soldering metal bump on the surface of the second electrode, the second soldering metal bump including the rest of the components of the eutectic alloy, wherein the second soldering metal bump has a second melting temperature;

aligning the first and second soldering metal bumps to each other, and then keeping both in contact with each other; and

heating the first and second soldering metal bumps at such a connection temperature that a connection part made of the eutectic alloy is formed between the first and second soldering metal bumps.

wherein the connection temperature is higher than the eutectic temperature and lower than the melting temperatures of the first and second soldering metal bumps.

18. (Amended) A method for fabricating an integrated electronic device according to claim 17, wherein the [soldering metal alloy consists of metal components same as metal components of an eutectic alloy and that a mixing ratio of the soldering metal alloy is deviated from a mixing ratio of the eutectic alloy, and an] eutectic temperature of the eutectic alloy is [lower] higher than a highest limit of an operating temperature of the integrated electronic device.

B1 Cont.
19. (Amended) A method for fabricating an integrated electronic device according to claim[18] 17, wherein one of the first and second soldering metal [alloy] bumps is [selected from the group consisting] made of at least a component of a binary alloy of In-Bi, a tertiary alloy of Sn-Bi-In [and] or a four-element alloy of Sn-Pb-Bi-In, and the other of the first and second soldering metal bumps is made of the rest of the components of the binary alloy, the tertiary alloy or the four element alloy.

20. (Amended) A method for fabricating an integrated electronic device according to claim[19] 17, wherein [indium is replaced by cadmium] one of the first and second soldering metal bumps is made of at least a component of a binary alloy of Cd-Bi, a tertiary alloy of Sn-Bi-Cd or a four element alloy of Sn-Pb-Bi-Cd, and the other of the first and second soldering metal bumps is made of the rest of the components of the binary alloy, the tertiary alloy or the four element alloy.

21. (Amended) A method for fabricating an integrated electronic device according to claim[19] 17, wherein [the soldering metal alloy of] the electric connection is [comprised of additional minor components that are harmless for the soldering metal alloy to have the liquid phase component at an operating temperature of the integrated electronic device] composed of Ge as an additional minor component.

Please add new claims 37-41as follows:

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--37. A method for fabricating an integrated electronic device having an electric connection connecting a first electrode of a first substrate with a second electrode of a second substrate, both

surfaces of the first and second electrodes having an adhesive tendency to molten metal, the method comprising the steps of:

forming a soldering metal bump on the surface of the first electrode, the soldering metal bump essentially consisting of components of an eutectic alloy having an eutectic temperature, wherein the soldering metal bump has a melting temperature higher than the eutectic temperature;

mounting the first substrate on the second substrate such that the soldering metal bump is aligned to the corresponding second electrode; and

melting the soldering metal bump at the melting temperature, and then solidifying the soldering metal bump into the electric connection connecting the first electrode with the second electrode.

38. A method for fabricating an integrated electronic device according to claim 37, wherein the eutectic temperature of the eutectic alloy is in the operating temperature range of the integrated electronic device.

39. A method for fabricating an integrated electronic device having an electric connection connecting a first electrode of a first substrate with a second electrode of a second substrate, surfaces of the first and the second electrodes having repellant and adhesive tendencies to molten metal, respectively, the method comprising the steps of:

forming a first and second soldering metal bumps on the surfaces of the first and second electrodes by depositing first and second soldering metals through the first and second masks, respectively, a melting temperature of the first soldering metal bump being higher than a melting temperature of the second soldering metal bump;

aligning the first and second soldering metal bumps to each other, and then keeping both in contact with each other; and

heating the first and second soldering metal bumps to melt the second soldering metal bump at a connection temperature lower than the melting temperature of the first soldering metal bump and solidifying the second soldering metal to form an electric connection between the first and second electrodes.

40. A method for fabricating an integrated electronic device according to claim 39, wherein the surfaces of the first and second electrodes are made of Al and Cu, Au, Ag or Sn, respectively.

41. A method for fabricating an integrated electronic device according to claim 39, wherein the first and second soldering metal bumps essentially consist of Pb and Sn, wherein Pb is contained less in the first soldering metal bump than in the second soldering metal bump.

REMARKS

Claims 17-21, 25, 26 and 37-41 are pending. Claims 17-21 are amended and new claims 37-41 are added. Non-elected claims 27-36 are canceled without prejudice or disclaimer.

The amendment filed September 9, 1999 was objected to under 35 USC § 132 as allegedly introducing new matter. Favorable reconsideration of the objection is respectfully requested.

The Office Action asserts that the amendment to page 15, last line, is not support by the original specification (in regard to the addition of silver). However, originally filed claim 23 provides support for the amendment to the specification. Accordingly, it is respectfully submitted that the amendment does not introduce new matter.

Claims 17-21, 25 and 26 were rejected under 35 USC § 112, second paragraph, as being indefinite.

The claims have been amended in response to the Examiner's objection.

Claims 17, 18 and 25 were rejected under 35 USC § 102(a) as being anticipated by Nelson et al. Favorable reconsideration of this rejection is requested in view of the amendments made herein.

Nelson et al. discloses a mechanical connection between the upper and lower electrodes being made of organic adhesive such as epoxy as indicated by elements 12, 30 and 42 in Figs. 3, 5 and 10, respectively. In contrast thereto, the mechanical and electric connection between the electrodes in the present invention are made only of soldering metals. Therefore, the processing steps of the claimed invention are not anticipated by Nelson et al.

Claims 19-21 and 26 were rejected under 35 USC § 103(a) as being unpatentable over Nelson et al. Favorable reconsideration of this rejection is earnestly solicited.

The presently amended claims are directed to selection of soldering metals having different melting temperatures and forming the electric connection to avoid the disconnection problem due to the repellency of the surface of the electrode against molten metal. Nelson et al. provides no teaching or suggestion concerning these features.

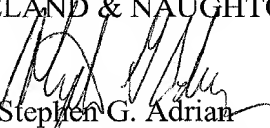
For at least the foregoing reasons, the amended claims distinguish over the cited art and define patentable subject matter. Favorable reconsideration is earnestly solicited.

Should the Examiner deem that any further action by applicants would be desirable to place the application in condition for allowance, the Examiner is encouraged to telephone applicants' undersigned attorney.

In the event that this paper is not timely filed, applicants respectfully petition for an appropriate extension of time. The fees for such an extension or any other fees which may be due with respect to this paper, may be charged to Deposit Account No. 01-2340.

Respectfully submitted,

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